



<b>AMORPHOUS POLYMERS</b>	<b>AMORPHOUS PLASTICS GENERAL PROPERTIES</b>		<b>SEMI-CRYSTALLINE PLASTICS GENERAL PROPERTIES</b>		<b>SEMI-CRYSTALLINE POLYMERS</b>		
	Soften over a wide range of temperatures Lower Specific Gravity Lower Tensile Strength and Tensile Modulus Higher Ductility Lower Creep Resistance Tend to be Transparent Higher Dimensional Stability Lower fatigue resistance Higher Surface Appearance Bond well using adhesives and solvents Lower Chemical Resistance and Résistance to Stress Cracking Structural applications only (not for bearing and wear)		 Random molecular orientation in both molten and solid phases.	Distinct & Sharp melting point Higher Specific Gravity Higher Tensile Strength and Tensile Modulus Lower Ductility Higher Creep Resistance Tend to be Translucent or opaque Lower Dimensional Stability Higher fatigue resistance Higher Surface Appearance Difficult to bond using adhesives and solvents Higher Chemical Resistance and Résistance to Stress Cracking Good for bearing and wear, as well as for structural applications		 Random molecular orientation in molten phase but densely packed crystallites in solid phase.	
	<b>AMORPHOUS PERFORMANCE PLASTICS</b>		<b>SEMI-CRYSTALLINE PERFORMANCE PLASTICS</b>				
	<b>KEY PROPERTIES</b>	<b>EXAMPLES</b>	<b>KEY PROPERTIES</b>	<b>EXAMPLES</b>			
	High cost High temperature resistance High strength and good stiffness High impact resistance Good chemical resistance Hot water and steam resistance	POLYSULPHONE (PSU) POLYETHERIMIDE (PEI) POLYETHERSULPHONE (PES) POLYARYLSULPHONE (PAS)	High cost High temperature resistance High strength Outstanding electrical properties Outstanding chemical resistance Low co-efficient of friction Good toughness	PVDF PTFE ECTFE FEP PFA PPS PEEK			
	<b>AMORPHOUS ENGINEERING PLASTICS</b>		<b>SEMI-CRYSTALLINE ENGINEERING PLASTICS</b>				
	<b>KEY PROPERTIES</b>	<b>EXAMPLES</b>	<b>KEY PROPERTIES</b>	<b>EXAMPLES</b>			
Moderate cost Moderate temperature resistance Moderate strength and stiffness Good impact resistance Good dimensional stability Typically translucent Good optical qualities	PC MODIFIED PPO MODIFIED PPE THERMOPLASTIC URETHANE	Moderate cost Moderate temperature resistance Moderate strength Good impact resistance Good chemical resistance Good bearing and wear properties Low co-efficient of friction Difficult to bond	PA (NYLON) POM (ACETAL) PET PBT PE-UHMW				
<b>AMORPHOUS COMMODITY PLASTICS</b>		<b>SEMI-CRYSTALLINE COMMODITY PLASTICS</b>					
<b>KEY PROPERTIES</b>	<b>EXAMPLES</b>	<b>KEY PROPERTIES</b>	<b>EXAMPLES</b>				
Low cost Low temperature resistance Low strength and stiffness Good dimensional stability Bond well Typically translucent	PMMA (ACRYLIC) PS ABS PVC PETG CAB	Low cost Low temperature resistance Low strength Good toughness Excellent chemical resistance Near zero moisture absorption Good electrical properties	PE-LD PE-HD PP POLYMETHYLPENTENE (TPX)				
<b>IMIDE MATERIALS</b>							
<b>KEY PROPERTIES</b>			<b>EXAMPLES</b>				
Very high cost Excellent high temperature properties Excellent dimensional stability Low co-efficient of friction			PI PAI PBI				

# COMMON POLYMERS - PROPERTIES AND APPLICATIONS

ABS - Acrylonitrile-Butadiene-Styrene	
Properties	Applications
Tough, hard and rigid and can be produced in high gloss colours. Good chemical resistance and dimensional stability; high creep resistance, can be electroplated, moderate strength, inexpensive. Tendency to stress crack.	Telephone handsets, electronic housings, luggage, auto parts, consumer products, pipe fittings, waste pipes, computer housings (electroplated on the inside), and automotive trim.

EP - Epoxy	
Properties	Applications
Rigid, clear and tough with good chemical resistance. Air curable, highly fillable, with low shrinkage and low susceptibility to stress formation. Good adhesion. High tensile strength. High heat resistance, high heat deformation resistance, good aging properties. Good electrical and dielectric properties. Odourless, tasteless, low flammability. Systems can be formulated to meet specific requirements.	Adhesives, coatings, encapsulation compounds, aerospace applications.

E/VAL - Ethylene vinyl alcohol	
Properties	Applications
Flexible and rubbery. E/VAL films are hydrophilic, crystal clear, glossy and do not need special antistatic treatments. Good barrier properties for gases and aromatic materials. Its permeability depends on temperature and humidity. It has a working range from 70 to -70°C. High coefficient of friction.	Flexible tubing for various applications from beer tubing to vacuum cleaner hoses, packaging of textiles. E/VAL powder coatings are used chemical plants, buildings, steel structures, roads, and offshore engineering.

Ionomer	
Properties	Applications
High impact strength at low temperatures, puncture and abrasion resistance, high melt elasticity, and good thermoforming properties. Low sealing temperatures, high sealing seam strength, resistance to grease, oil, and solvents	Tough, scratch-resistant golf balls, footwear components, glass coatings, abrasion resistant surfaces and buoys. Can replace glass and be used in packaging films and sealants.

LCP - Liquid Crystal Polymer	
Properties	Applications
Excellent strength but expensive. Good high temperature properties, can be used in thin walls (as thin as 0.2 mm). Parts can withstand autoclaving to 135 °C. High chemical resistance and flame retardancy. Very low coefficient of thermal expansion. High tensile modulus from 10 to 24 GPa.	High-performance engineering applications such as electrical connectors and machine parts. Surgical devices.

MF - Melamine formaldehyde	
Properties	Applications
Hard, opaque (but wide colour range), tough with high surface hardness and scratch resistance. High resistance to creep, heat, moisture, boiling water. High shrinkage, easy to crack.	Decorative laminates, lighting fixtures, picnic ware, toilet seats, general purpose moulding compounds and food containers (e.g. dishes).

PA - Polyamide (Nylon)	
Properties	Applications
Rigid translucent and tough with moderate strength. Inexpensive but poor dimensional stability due to water absorption (hygroscopic nature). Available in many different forms and the mechanical properties can be significantly improved by the use of glass fibre reinforcement. Generally resistant to fuels and oils (dependent on type of PA used). Steam sterilisable.	Gear wheels, zips, bearings, pressure tubing, kitchen utensils and blow mouldings, and clothing fabrics.

PB - Polybutylene	
Properties	Applications
Semi-rigid, tough with high flexibility (even at low temperatures), high abrasion resistance, high resistance to chemical attack, and good resistance to hot water and to stress cracking. Good barrier properties but has poor handling in the form of semi-finished goods and mouldings after processing because of the start of crystal rearrangement.	Boil-in-the-bag films, industrial pipes, tubes and sheets. Used for central heating system pipes and components because of good resistance to hot water.

PC - Polycarbonate	
Properties	Applications
Excellent strength and toughness with good dimensional stability, dielectric strength, flame retardancy and impact resistance (best among clear rigid materials). Susceptible to stress cracking with aromatic solvents and is difficult to machine.	Riot shields, optical lenses and headlamp sets, vandal proof glazing, medical items, safety helmets, CD's, and power tool housings.

PE - Polyethylene (Low Density: PE-LD, Linear Low Density: PE-LLD, High Density: PE-HD)	
Properties	Applications
PE is really a family of polymers and all have varying properties. PE-LD/PE-LLD: Flexible, translucent with a waxy feel and has good toughness at low temperatures and low cost. PE-HD: Semi-rigid, translucent and very tough, good chemical resistance with low water absorption and low cost.	PE applications vary with the type of material. PE-LD/PE-LLD: Squeeze bottles, toys, carrier bags sacks and other packaging. Gas and water pipes. PE-HD: Kitchen ware, chemical drums, carrier bags, food wrapping materials. Car petrol tanks.

PEEK - Polyether ether ketone	
Properties	Applications
High tensile and flexural strength, high impact strength, and a high fatigue limit. High heat distortion temperature, high chemical resistance, and high radiation resistance. Good electrical properties, good slip and wear characteristics, and low flammability. Easy processing, no thermal after-treatment of injection moulding.	Microwave grills, nuclear reactor components, surgical tools.

PES - Polyether sulphone	
Properties	Applications
This expensive material is electroplatable, has high strength, good toughness, good dielectric strength, and dimensional stability.	Electric connectors.

PET - Polyester	
Properties	Applications
Rigid, clear and extremely tough with excellent dimensional stability and high dielectric strength. Moderate chemical resistance, low resistance to strong acids and bases, is notch sensitive, not for outdoor use or in hot water.	Carbonated drink bottles, video and audio tapes, clothing and handles.

PF - Phenol formaldehyde (Phenolic)	
Properties	Applications
Hard brittle opaque but can be strengthened with fillers such as wood pulp and cellulose. Good electrical properties and chemical and heat resistance.	Ashtrays, lamp holders, saucepan handles and early consumer electronic products such as telephones and radios.

PI - Polyimide (Aramids)	
Properties	Applications
Rigid, opaque with high impact and dielectric strength, high heat resistance (260°C continuous, up to 480°C intermittent), and a low coefficient of thermal expansion.	Bearing materials, thrust washers, and semiconductor wafer clamps.

PMMA - Polymethyl methacrylate	
Properties	Applications
Hard, rigid, glass clear with good weather resistance and can be used in casting, thermoforming and fabricating.	Signs and leaflet dispensers, automotive lens clusters, lighting diffusers.

POM - Polyacetal (Acetal)	
Properties	Applications
Rigid, translucent and tough with good spring like qualities. It has good dimensional stability and resistant to creep and fatigue. High abrasion and chemical resistance.	Business machine, toys, handles and knobs, aerosol valves, clock and watch parts and bearings.

PPO - Polyphenylene oxide	
Properties	Applications
Rigid, opaque. Easily attacked by some hydrocarbons, although it resists many chemicals. Excellent dimensional stability, low moisture absorption, and high mechanical and dielectric strength.	Coffee pot and washing machine parts, microwave components.

PPS - Polyphenylene sulfide	
Properties	Applications
High temperature resistance (with non-burning continuous use at 240°C), low temperature endurance, good chemical resistance, and flame retardance.	Chemical pumps, high performance electrical connectors, medical equipment, TV and automotive components and other high stress parts.

PP - Polypropylene	
Properties	Applications
High lubricity and high resistance to flexing (excellent for living hinges), excellent dielectric strength and chemical resistance, good impact strength, and high solvent resistance. Can be sterilised by steam and has good heat resistance. It is inexpensive and electroplatable. It is difficult to paint, print on, or bond to. It will be attacked by fuming nitric acid and degraded by UV and ionising radiation.	Sterilisable hospital ware, medical syringes, beakers, and parts for auto interiors, vacuum flasks.

PS - Polystyrene	
Properties	Applications
Brittle (except in high impact grades: PS-HI), easy to mould, it is inexpensive, machines well, and possesses excellent transparency. Low mechanical strength.	Inexpensive packaging materials, pens, safety razors, flatware, and CD jewel boxes. In foam format, PS is used to make high-throughput, thin-walled, easy-to-mould parts such as disposable coffee cups.

PTFE - Polytetrafluoroethylene and other fluoroplastics (FEP, PFA, CTFE, ECTFE, ETFE)	
Properties	Applications
Semi-rigid, translucent with exceptionally low coefficient of friction and excellent chemical resistance. High temperature stability (to 260°C) and low temperature toughness (to -160°C). Good weathering resistance and electrical properties. Low mechanical strength. Expensive.	Non-stick coatings, gaskets, packings, bearings, high and low temperature electrical and medical products, other uses needing excellent dielectric strength, chemical, and temperature resistance.

PU - Polyurethane	
Properties	Applications
Flexible, clear, highly elastic with high impact resistance, dielectric strength, chemical resistance, and abrasion resistance. It can be made into films, solid mouldings, or flexible foams. Outdoor exposure turns brittle.	Soles and heels for sports shoes, automotive structural members, computer housings, furniture, seals and gaskets, skateboard wheels and packaging foams.

PVC - Polyvinyl chloride	
Properties	Applications
PVC is one of the most versatile of all polymers. The polymer cannot be used in the natural state but compounding can create an enormous range of properties from rigid products (window frames) through to flexible sheets and hoses. Flexible grades are easy to process. Rigid grades have a high dielectric strength, outdoor stability, chemical resistance, good moisture stability, and low cost. Material has low heat resistance.	Pipes and fittings, wire and cable insulation, window profiles, extruded film and sheet, and medical applications.

SI - Silicone	
Properties	Applications
Possesses dimensional stability and good electrical and dielectric properties over wide frequency and temperature ranges. It has flame resistance, low water absorption, moderate thermal shock resistance, and average polymeric mechanical properties. It has a high cost, limited shelf-life, and a long curing time.	Computer chips, IC, cooking ware, and food containers, high performance window seals.

SAN - Styrene acrylonitrile	
Properties	Applications
Rigid, transparent and tough, resistant to stress cracking and crazing.	Sterilisable hospital ware, medical syringes, beakers, and parts for auto interiors, vacuum flasks.

## THERMOPLASTICS PROCESSING METHODS - FEATURES

Processing Method	Equipment Cost	Tooling Cost	Cycle Time	Precision	Economic Quantity	Wall Thickness	Enclosed Volumes	Very Small Items	Intricate Shapes	Inserts	Threads
Injection Moulding	High	High	< 1 min	Good	> 10K	Good control	No	Yes	Yes	Yes	Yes
Blow Moulding	High	Moderate	< 1 min	Moderate	> 10K	Poor control	Yes	No	Yes	No	Yes
Extrusion	High	Moderate	Continuous	Good	> 5 km	Good control	No	No	Yes	No	No
Rotational Moulding	Moderate	Low	> 3 min	Moderate	100 to 10K	Poor control	Yes	No	No	Yes	No
Thermoforming	Moderate	Low	1 - 3 min	Poor	100 to 10K	Poor control	No	No	No	No	No

## THERMOPLASTICS PROCESSING METHODS - MATERIALS

Processing Method	ABS	EVA	PA	PC	PE-LD	PE-HD	PMMA	POM	PP	PS/PS-HI	PVC-U	PVC-P	SAN
Injection Moulding	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blow Moulding	No	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Extrusion	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rotational Moulding	Yes	Yes	Yes	No	Yes	Yes	No	No	No	Yes	Yes	Yes	No
Thermoforming	Yes	Low	No	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	No

## THERMOSETS PROCESSING METHODS

Processing Method	Equipment Cost	Tooling Cost	Cycle Time	Precision	Economic Quantity
Comp. Moulding	Moderate	High	2 - 5 min	Good	> 10K
Transfer Moulding	Moderate	High	2 - 5 min	Good	> 10K
Injection Moulding	High	High	< 2 min	Good	> 10K
Liquid Casting	None	Low	> 5 min	Moderate	<100
DMC and SMC	Moderate	High	2 - 5 min	Good	> 10K
RIM and RRIM	Moderate	Moderate	2 - 5 min	Moderate	100 to 10K
GRP (Hand Layup)	None	Low	> 5 min	Poor	<100
GRP (Spray & Match)	Moderate	Moderate	2 - 5 min	Moderate	100 to 10K
Filament Winding	Moderate	Low	> 5 min	Poor	<100
Pultrusion	Moderate	Moderate	Continuous	Moderate	> 5 km